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METHOD FOR THE PRODUCTION OF DROP FORGE PARTS CONTAINING Ti, Zr, Hf

The invention concerns a process for production of drop forged parts, which are essentially comprised of titanium, zirconium, hafnium or a corresponding alloy. Besides this, the invention concerns drop forged parts of this type.

Titanium, in particular, is an interesting light metal, since it is almost 50% lighter than steel. For this reason Ti, Zr and Hf components are interesting in the manufacture of motor vehicles, particularly if unsprung or rotating, for example, oscillating masses are to be reduced. In this connection drop forged parts (of bar stock, wires), in particular forged connecting rods, crankshafts and camshafts or valve parts can be mentioned. Titanium however exhibits, in comparison to metallic materials, a comparatively low modulus of elasticity (abbreviated: E-modulus in GPa; Materials Properties Handbook: Titanium Alloys, Editors: Boyer, Welsch, Collings, ASM International, Materials Park, OH 44073-002). Thus, the E-modulus of titanium alloy is approximately 90 GPa, that of steel is approximately 210 GPa, that of Al-alloys is approximately 70 GPa and that of Mg-alloys is approximately 30-40 GPa.

Drop forged moving titanium parts of motors, such as, for example, connecting rods, crankshafts, camshafts and/or valve parts, can as a result tolerate only low loads.

In the state of the art, coating processes for components are described, which lead to a hardening of the titanium alloy. DE 36 15 425 concerns a time and labor intensive plasma coating process for improving abrasion resistance of surface layers of titanium alloy machine components.

It is the task of the present invention to provide a process for production of drop forge parts, which are comprised essentially of Ti, Zr, Hf or a corresponding alloy, in which a higher E-modulus of the drop forge parts is achieved.

The task is solved by a process, in which materials containing 80 wt. % or more Ti and/or Zr and/or Hf, or alloys thereof, during deformation, are heated 5-15K above the α / β phase boundary (transition temperature) and subsequently are cooled. Preferably, the heating takes place over a period of approximately 20-60 minutes. Thereby it is achieved, that the E-modulus

and rigidity of the employed Ti, Zr, Hf materials is increased in and during the manufacture of drop forge parts.

With the aid of the inventive process the oscillating mass in a motor, in particular connecting rods, crankshafts and camshafts and/or valves, can be reduced up to 35% or more, in comparison with steel components. Advantages are achieved with respect to improved motor dynamics, lower noise emissions, dispensing of the Lancester counter-weight as well as savings in fuel.

As the Ti, Zr, Hf materials, suited for purposes of the invention are titanium as such, zirconium as such, hafnium as such; preferred however are alloys containing up to 80 wt. % or more Ti and/or Zr and/or Hf, preferably 90 wt. %. Particularly preferred are however titanium alloys with 80 wt. % titanium, preferably 90 wt. % titanium. Zr and Hf can be contained as minor components in the range of 1-20 wt. %, preferably 5-15 wt. %. Likewise, incidental amounts of conventional metals can be contained, such as Al, Si, Mg, Se, Ni, Co, Mo, V or other light and heavy metals. Further preferred alloys for employment in motor vehicle construction include Ti Al 6 V 4 or Ti Al 6 Fe2 Si.

In accordance with the invention, α / β – Ti-alloys or, as the case may be, α / β – Ti containing materials are employed which have both a high strength, cubic space-centered β-phase as well as hexagonal α-phase with high E-modulus. In the so-called high temperature deformation, more β-phases are produced and in the low temperature deformation, more α-phases are produced. In accordance with the invention, deformation occurs in the α / β zone, and namely, with heating 5-15°C, preferably 8 – 10 – 12°C above the α / β phase boundary (transition temperature). With pure titanium, for example at 882.5 °C, α-Ti transitions into β-Ti (so-called α / β phase boundary limit), that is, the heating should inventively occur at 887-897°C. For Ti Al 6 V 4 or Ti Al 6 Fe 2 Si, the corresponding preferred heating value is 975°C ± 15°C.

The duration of heating in the indicated temperature range is at least to twenty minutes to forty-five minutes or longer, preferably however not longer than one hour.

Thereby, during heating, the α-low temperature phase is replaced by the β-high temperature phase in such a manner, that an α / β microstructure, or as the case may be, an

inventive composite, is produced (Fig. 1), which combines the high strength characteristics of the β phase with the higher E-modulus of the α phase. This temperature-dependent deformation range is to be selected very narrowly, or as the case may be, heating or deformation temperatures are to be adjusted to ± 15 K, preferably ± 5 K, from the optimal deformation temperature of 10 K above the α / β phase limit. Departing from this range, then either isolated α or β phases exists in a β or, as the case may be, α base matrix (Fig. 2), so that disadvantageously the low E-modulus of the β phase results. The desired α / β microstructure or grain structure can be improved inventively with respect to a stronger interlacing of the α and β phases, in that after the deformation, it is slowly cooled in air or, as the case may be, in a gas atmosphere. Thereby the α / β microstructure is further interfused by the α-phase. As a result, an alternating of the arrangement of the α phase and the β phase in the material is achieved. Basically, a mixed phase in an α / β web structure is obtained. Inventively, after the deformation, a relaxation treatment can follow at 650 ± 50°C in order to achieve, besides the reduction of undesired deformation tensions, a stronger intermixing of the α / β microstructure with the α-phase with high E-modulus (Fig. 3). Thereby, the heating or glowing time is to be limited in such a manner that the α / β microstructure is not destroyed. With these Ti connecting rods drop forged at 975°C ± 5°C, which after the deformation are slowly cooled in air, there can be achieved in an α / β alloy Ti Al 6 V with an E-modulus of 130 GPa or, as the case may be, a Ti Al 6 Fe2 Si an E-modulus of 140 GPa be realized. A subsequent relaxation heating at 650°C brings about an additional E-modulus increase of at least 5 GPa. The break elongation achieved by the inventive process lies, in the case of alloys, (for example, Ti Al 6 V 4 Ti Al 6 Fe2 Si) at above 1,100 MPa or, as the case may be, the technical elastic limit lies above 1,000 MPa. This corresponds to the rigidity values of high stiffness β – Ti alloys, which lie above that of steel. Thus, advantageously the oscillating mass can be reduced by up to 35% - 45% in the case of Ti Al 6 Fe2 Si connecting rods in comparison to high stiffness steel connecting rods.

Description of the figures:

Fig. 1:

α / β web arrangement (microstructure) of a Ti connecting rod of Ti Al 6 Fe2 Si forged at 975°C (white α- and grey β- lamella).

Fig. 2:

α / β web arrangement (microstructure) of a Ti connecting rod forged at 990°C of Ti Al 6 Fe2 Si with isolated white α islands.

Fig. 3:

α / β web arrangement (microstructure) of a Ti connecting rod of Ti Al 6 Fe2 Si deformed at 975°C and then relaxation treated at 650°C (white α- and grey β- lamella).